# PHYSICAL PROPERTIES OF SHOE UPPER MATERIALS AND THEIR EFFECT ON FOOTWEAR COMFORT*

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*ABSTRACT*

*A comparative study of full chrome retanned and semichrome leathers with synthetics is made. Various physical properties such as water absorption, water penetration, water vapour permeability, effect of wetting and drying, rate of drying, resistance to perspiration, tensile strength, elongation, percent set, flexibility, apparent density and resistance to heat and cold of the upper materials are measured. The results obtained are discussed from the points of view of comfort.*

The properties of footwear materials which contribute the wearer's comfort is a subject of universal interest. But very little work has been done on this very important subject of foot comfort. Obviously foot comfort depends on the absence of painful pressures anywhere on the foot, and on keeping it warm in cold weather and cool in hot weather. Comfort in footwear concerns with the physiology of the foot, environmental conditions and the physical properties of the materials used. This study mainly concerns with the physical properties of upper materials. The important properties of uppers which will influence the comfort of the footwear are : (1) water vapour permeability, (2) Moisture absorption and desorption, (3) Area stability, (4) Effect of wetting and drying, (5) rate of drying, (6) water absorption, (7) water penetration, (8) water vapour absorption, (9) perspiration resistance, (10) lightness, (11) Flexibility, (12) Plasticity of leathers, (13) Tensile strength, (14) Elongation, (15) Stitch tear strength, (16) Resistance to cold and (17) Resistance to heat. Hence these properties of the various materials were measured and the results obtained are discussed from the points of view of comfort.

## Experimental Procedure

All samples were conditioned for a week at 65% ±2% relative humidity and 80°±4°F temperature and then tested.

Full chrome, chrome retanned and semi-chrome leathers and synthetics were used. All the leather samples were obtained from the butt portion.

For finding out the water absorption, Kubelka's apparatus[1] was used. The method suggested by Mitton[2] and approved by the physical Testing Commission of International Union of Leather Chemists[3] was used for determining the water

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$$\text{The percentage water vapour absorption after 24 hours} = \frac{\text{Weight at 100\% r.h.—weight at 0\% r.h.}}{\text{weight at 0\% r.h.} \times 100}$$

**Perspiration Resistance**

The samples were subjected to treatment with artificial perspiration and the cracking observed after bending the material through 180 degrees (KKL-311a method 3211)[12]

**Lightness**

Samples of the same size were cut from the same location on the side and weighed.

**Resistance to Cold**

This method is of use in determining the resistance of leather to cracking on being bent at low temperatures. The specimen (a rectangle of leather 2 inch in length and 1 inch in width) was placed in a cold chamber (-20°C) for 2 hours. While remaining in the cold chamber at the specified temperature, the specimen was folded cross-wise sharply on itself with the grain side of the leather out. The folded specimen was examined for any crack in the area around the bend.

**Resistance to Heat**

This method is of use in determining the effect of elevated temperatures on leather under normal atmospheric pressure and controlled humidity. The leather (test specimen) was heated for 45 minutes in an oven maintained at 150±3°C. The leather was heated dry. Immediately after removal from the oven the samples were tested for cracking.

**Results and Discussion**

*Water vapour permeability*

As a general purpose upper material should have high water vapour permeability. This property was measured for various upper materials. The results are given in Table 1. It is seen that for the synthetic substitute uppers the value is low. Full chrome uppers exhibit the highest value. The enormous surface area of the fibres in leather enables it to take up water vapour rapidly and to convey it to the outside air. The transmission of water vapour is favoured because it is transmitted by and through the substance of the leather fibres themselves. The greatest water vapour permeability of chrome leather is due to its greatest surface area. Previous studies[13,14] proved that impermeable uppers lead to increased sweat retention in the boots and socks. Kennedy *et al*[13] observed that the sweat or water vapour absorption capacition of the boots with the Melovin uppers were exceeded on many test days, giving

semi-chrome and chrome retanned leathers. This may be due to the difference in the nature of the tanning, thickness and porosity of the samples. The rate of drying of synthetics is very poor. The reservoir capacity of the samples is in the reverse order. The rate of evaporation decreases with time and would thus seem to depend on the quantity of water contained in the samples. As the shoes are likely to become wet especially in winter season or in the cold countries, the rate of drying of upper materials assumes great importance.

**Water Absorption, Water Penetration and Water Vapour Absorption**

Functional footwear is expected to keep the feet dry by resisting the moisture from the outside, and by absorbing moisture from perspiration from the inside and allowing the same to evaporate. Shoes that cannot brush off external water obviously rot and deteriorate quicker than the water resistant ones. Hence the upper materials were tested for these properties and the results are given in Table 1. The results show from the point of view of the properties of water absorption, water penetration and water vapour absorption, which properties may be expected to influence comfort from a physiological stand-point, for normal conditions, full chrome appears to be better as it allows a greater amount of water vapour to pass through and at the same time absorbs water vapour to a fair extent. However, if the ambient conditions are very wet, the increased water absorption of full chrome compared to semi-chrome might make semi-chrome better. Even though the synthetic uppers have the maximum water resistance, their water vapour permeability and water vapour absorption characteristics are very poor.

**Perspiration Resistance**

Chrome retan has poor resistance to perspiration whereas the semi-chrome and the synthetics have the maximum resistance to perspiration. The perspiration resistance of chrome upper is poor. So semi-chrome upper leathers can be used for a comfortable footwear.

**Lightness**

Although we are provided with many strong muscles, the muscles which lift the foot and lower leg in walking are relatively weak and any extra weight which is placed on the feet becomes a burden. It has been estimated that one pound extra weight on the feet is equivalent to ten pounds extra on the back. Hence the weight per unit area of various materials were measured and the results are given in Table 1. Comparing full chrome, semi-chrome and chrome retanned leathers, chrome retanned leather is heavier than the other. The synthetics are having the lowest weight. The values for the apparent density also confirms this.

**Flexibility**

Flexibility of uppers is very important to shoe comfort. Hence this property was measured and the results are given in Table 1. The results showed that the syn-

**Plasticity**

An upper leather must meet the stringent mechanical requirements of the "lasting" process. Lasting is, perhaps the key process in shoe-making, since it is at this stage that the shape of the shoe is imposed on the materials from which it is made. Ideally, a material for shoe upper should be capable of being made to conform to the last in a few seconds, of retaining this shape on removal of the last—even after being worn and yet still making minor adaptations of shape to fit the foot of the individual wearer while standing or walking. The plasticity of the full chrome is more than that of semi-chrome and chrome retan and synthetics have low percent set.

**Tensile Strength, Elongation and Stitch Tear**

These properties were measured and the results are given in Table 1. The results given in the table show that the synthetics upper have lower strength. The stretchiness in synthetic materials is generally higher than in the leather samples. Among leathers chrome leather is having higher strength and higher elongation.

**Resistance to Cold and Heat**

If the upper material is having poor resistance to cold, it may become hard and thus will affect the comfort. Similarly, if the uppers are having a poor resistance to heat, it may be become soft and affect the comfort. Hence this was studied and the results are given in Table 1. Chrome and semi-chrome leathers are having a good resistance to heat and cold. The synthetics become stiff at cold temperature and more flexible at hot temperatures.

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